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Breeding habits and associated phenomena in some Indian bats

Part I—*Rousettus leschenaulti* (Desmarest)—Megachiroptera[1]

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(*With a plate and two text-figures*)

The following report is based on the examination of 1367 specimens of the Indian fruit bat, *Rousettus leschenaulti* (Desmarest) collected at frequent intervals at and near Aurangabad, Maharashtra during a period of about two years and a half. There is no segregation of the specimens on the basis of sex, age or season. The uterine cornua open independently through separate cervical canals into the vagina. Each female experiences two pregnancies in quick succession in the year. The first pregnancy starts in the second week of November and terminates in the middle of March. The second pregnancy starts soon after parturition and goes until the last week of July. Gestation lasts for about 125 days. The early part of the second pregnancy overlaps the lactation period of the first pregnancy cycle. The animals are sexually quiescent from August to November. While most of the females in the colony become pregnant in November, a few become pregnant in the third week of December and deliver their young during the last week of April or early in May. After December all the females in the colony are pregnant. During each pregnancy only one uterine cornu bears a single embryo, and the two uterine cornua function alternately in successive cycles in bearing pregnancy. Whereas the females reach sexual maturity within five months of age, the males do not attain sexual maturity until they are at least 15 months old. There is a balanced sex ratio at birth, but in the adult stage the females out-number the males.

Introduction

Most of the early record on the reproduction of Megachiroptera are in the nature of casual references to the occurrence of pregnant specimens during certain seasons of the year while reporting on some other aspect of the biology of bats. An excellent review of the previous work on the reproduction of fruit bats was given by Baker & Baker (1936), and more recently by Asdell (1964), who compiled a valuable bibliography of the earlier work on

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the reproduction of fruit bats. From these reviews it is evident that most of the fruit bats, both in northern and southern hemispheres, tend to copulate in the respective "Autumn" and give birth to the young in the following "Spring".

Baker & Baker (1936), who were the first to make a detailed study of the breeding habits of fruit bats, *Pteropus geddiei* and *Pteropus eotinus* from Hog Harbour, New Hebrides (15° 15′ S), noted that these species have a sharply defined breeding season although living in an almost unvarying tropical climate, and that they copulate in February-March (Southern Autumn) and deliver the young during August-September (Southern Spring) bringing forth a single young each time.

Marshall (1947) reported that *Pteropus giganteus* from Sri Lanka has a sharply defined annual breeding season despite the climatic stability of its habitat. According to the author, this species conceives from early December until early January, and the young ones are delivered late in May or early in June. Pregnancy lasts for about six months and a single young is born to each female. Ramakrishna (1947) noticed that *Cynopterus sphinx sphinx* at Bangalore (South India) experiences postpartum oestrus and that at least two pregnancies occur in quick succession in the year. He also noted that gestation lasts for about five months in this bat.

Moghe (1951) noted that *Pteropus giganteus* in Central India copulates late in August or early in September and that a single young is delivered by each female towards the end of January or February, the gestation being of 140 to 150 days. Moghe's (1951) observations differ from the observations of Marshall (1947) on the same species, but in Sri Lanka, thereby indicating that this species differs in its reproductive habits in different regions with different climatic conditions. Brosset (1962a), while studying the ecology of *Rousettus leschenaulti*, mentioned, "from the data available, this species appears to have two periods of parturition every year, the first in March and the second in August, the latter concerning a small number". Each time a single young is born. With respect to *Pteropus giganteus* he reported that "the periodicity of the reproductive cycle is very regular, and that only a single parturition takes place every year at least in Western India". In a preliminary note Gopalakrishna (1964) reported that *Rousettus leschenaulti* breeds more than once in the year, that the females undergo copulation within a short time after the young are delivered in April, and that a single young is born each time. Pregnancy alternates between the two uterine cornua in successive cycles.

Mutere (1965 & 1967) noted the occurrence of delayed implantation in the tropical African fruit bat, *Eidolon helvum*, which has a strict periodicity of reproduction although inhabiting a region almost squarely on the equator (latitude 0° 20′ N). Copulation in this species is immediately followed by fertilization during April-June, but the implantation of the embryo does not take place until about October. Unimplanted embryos were present in the uterus between June and October. Progressively advanced stages of the embryo were noticed from October to February and deliveries occurred during February and March. Although the uterus is bicornuate and perfectly symmetrical, ovulation and pregnancy occur only on one side, either right or left, with about equal frequency, but never on both sides at the same time.

The foregoing review of earlier literature reveals that not only is there no detailed study of the breeding habits of any Indian fruit bat,

Date	Immature Attached to mother	♂♂		Total of ♂♂	Immature Attached to mother	Non-pregnant			Adult				Total of ♀♀	Grand Total
									Non-lactating		Pregnant Lactating			
		Free	Adult			Free	Non-lactating	Lactating	Right horn	Left horn	Right horn	Left horn		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
7-i-65	—	2	3	5	—	—	—	—	11	6	—	—	17	22
8-i-65	—	2	6	8	—	—	—	—	3	2	—	—	5	13
11-i-65	—	2	13	15	—	—	—	—	6	15	—	—	21	36
16-i-65	—	2	8	10	—	—	—	—	9	3	—	—	12	22
25-i-65	—	3	10	13	—	—	—	—	13	3	—	—	16	29
27-i-65	—	1	21	22	—	—	—	—	7	17	—	—	24	46
8-ii-64	—	5	17	22	—	—	—	—	9	21	—	—	30	52
9-ii-65	—	7	6	13	—	—	—	—	6	11	—	—	17	30
26-ii-65	—	4	7	11	—	—	—	—	3	3	—	—	6	17
28-ii-64	—	3	13	16	—	—	—	—	4	13	—	—	17	33
12-iii-64	—	1	7	8	—	—	—	—	8	16	—	—	24	32
13-iii-65	1	9	14	24	—	—	—	1	5	4	—	—	10	34
18-iii-65	4	4	8	16	2	—	—	1	2	1	2	3	11	27
22-iii-64	1	—	10	11	—	—	—	—	6	9	—	1	16	27
27-iii-66	1	—	1	2	3	—	—	—	1	3	1	3	11	13
29-iii-65	—	4	3	7	2	—	—	—	1	—	1	1	5	12
3-iv-64	7	2	8	17	8	—	—	—	8	4	7	8	35	52
5-iv-64	12	2	7	21	9	—	—	—	3	8	14	7	41	62
5-iv-65	2	3	3	8	2	—	—	—	—	4	—	4	10	18
8-iv-64	3	3	5	11	2	—	—	—	3	2	1	5	13	24
13-iv-64	3	4	13	20	—	—	—	—	1	7	3	2	13	33
13-iv-65	1	3	3	7	—	—	—	—	—	1	—	—	1	8
15-iv-66	2	1	1	4	5	—	—	—	1	5	—	2	13	17
19-iv-65	3	2	9	14	4	1	—	—	2	4	2	7	20	34
24-iv-65	3	1	3	7	6	—	—	—	—	4	1	5	16	23
1-v-65	1	1	13	15	2	2	—	—	—	2	3	—	9	24
7-v-66	—	—	2	2	3	—	—	3	—	—	1	5	12	14
10-v-65	1	2	2	5	—	—	—	—	—	—	1	—	1	6
13-v-65	1	1	6	8	—	2	—	—	—	1	1	—	4	12
19-v-65	—	5	1	6	—	9	—	—	—	4	—	—	13	19
22-v-65	—	—	5	5	—	—	—	—	1	—	—	—	1	6
23-v-65	—	4	1	5	1	2	—	—	—	1	—	—	4	9

TABLE 1 (Contd.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1-vi-65	—	8	1	9	—	5	1	—	—	5	—	—	11	20
3-vi-64	—	1	4	5	—	—	—	—	1	2	—	—	3	8
9-vi-65	—	5	6	11	—	3	1	—	5	11	—	—	20	31
26-vi-64	—	1	1	2	—	—	—	—	1	1	—	—	2	4
27-vi-65	—	8	3	11	—	13	3	—	1	2	—	—	19	30
10-vii-65	—	6	—	6	—	8	—	—	—	2	—	—	10	16
16-vii-64	—	—	3	3	—	6	4	—	—	—	—	—	10	13
24-vii-65	2	2	6	10	2	2	6	10	—	—	—	—	20	30
17-viii-65	1	1	11	13	—	—	6	1	—	—	—	—	7	20
18-viii-64	—	—	1	1	—	—	—	—	—	—	—	—	—	1
26-viii-64	—	2	1	3	—	1	3	—	—	—	—	—	4	7
1-ix-64	—	1	1	2	—	1	3	—	—	—	—	—	4	6
5-ix-65	—	—	6	6	—	1	5	—	—	—	—	—	6	12
14-ix-65	—	2	4	6	—	2	9	—	—	—	—	—	11	17
19-ix-64	—	1	6	7	—	3	4	—	—	—	—	—	7	14
21-ix-64	—	3	5	8	—	3	3	—	—	—	—	—	6	14
7-x-65	—	—	5	5	—	2	8	—	—	—	—	—	10	15
17-x-65	—	1	3	4	—	1	8	—	—	—	—	—	9	13
2-xi-64	—	3	3	6	—	—	2	—	—	—	—	—	2	8
2-xi-65	—	4	7	11	—	3	8	—	—	—	—	—	11	22
6-xi-65	—	8	3	11	—	4	7	—	—	—	—	—	11	22
9-xi-65	—	2	6	8	—	—	—	—	2	10	—	—	12	20
17-xi-64	—	1	4	5	—	1	—	—	1	—	—	—	2	7
20-xi-65	—	1	3	4	—	—	—	—	9	3	—	—	12	16
22-xi-64	—	2	3	5	—	—	—	—	5	—	—	—	5	10
27-xi-64	—	2	16	18	—	—	—	—	10	2	—	—	12	30
2-xii-64	—	6	13	19	—	1	—	—	13	4	—	—	18	37
7-xii-64	—	6	5	11	—	1	—	—	11	1	—	—	13	24
10-xii-65	—	—	4	4	—	—	—	—	8	3	—	—	11	15
19-xii-64	—	3	10	13	—	—	—	—	11	—	—	—	11	24
22-xii-65	—	4	2	6	—	—	—	—	9	2	—	—	11	17
30-xii-64	—	5	12	17	—	—	—	—	18	3	—	—	21	38

but the little information which is available, indicates that there are considerable differences in the breeding habits of the different species. Hence, it was felt that a detailed study of the reproductive biology of the Indian fruit bat, *Rousettus leschenaulti* would be of interest and value.

Material and methods

The specimens of *Rousettus leschenaulti* were collected at random at frequent intervals from an underground tunnel near Bibika-Mukbara at Aurangabad, Maharashtra State. A few collections were also made from the dungeons of a dilapidated fort near Kandar about 200 air kilometres from Aurangabad. No segregation of the specimens on the basis of sex, age or season was noticed in either of the localities.

Collection of specimens was started on 11th January 1964 and continued until 7th May 1966 in such a manner that every calendar month of the year is represented by one collection or more. A collection diary mentioning the details of the description of each specimen was maintained. Table 1 gives the summary of the collection diary, and table 2 gives the month-wise distribution of the collections.

The specimens were killed by chloroform and, after recording their body weights, they were dissected and the reproductive organs and the accessory reproductive structures were removed and fixed in various fixatives. The tissues were sectioned at 8 to 10 μ thickness after following the usual procedure of dehydration by passing through graded series of ethanol and embedding in paraffin. The sections were stained in Ehrlich's haematoxylin and counterstained with eosin and mounted in DPX after clearing in xylol.

Altogether 1367 specimens were studied for the present work. The group of specimens collected on a given date exhibited almost the same characteristics during the three years the observations were made. Hence, in the following descriptions only the date and the month are mentioned where pertinent except where the mentioning of the year has a special significance.

Table 2

Monthwise collection of specimens

Month	♂♂	♀♀	Total
Jan.	73	95	168
Feb.	62	70	132
Mar.	68	77	145
Apr.	109	162	271
May	46	44	90
June	38	55	93
July	19	40	59
Aug.	17	11	28
Sept.	29	34	63
Oct.	9	19	28
Nov.	68	67	135
Dec.	70	85	155
Total	608	759	1367

Observations and discussion

1. *Morphology of the female reproductive organs*

As in most other species of bats so far described, excepting the members of the family Phyllostomatidae, the uterus is bicornuate and the uterine cornua are morphologically symmetrical. The ovaries, which are ellipsoidal in shape, are slightly flattened dorsoventrally. The ovarian bursa has an oblique slit-like opening on its median side so that the peri-ovarial space is in communication with the peritonial cavity. The Fallopian tube on each side arises on the mesial aspect of the ovarian bursa adjacent to the slit in the bursa, curves

towards the lateral sides after passing across the ventral aspect of the ovary, and opens near the cranial end of the uterus. Although the two uterine cornua meet externally their lumina remain separate, and open into the vagina through independent cervical canals. The cranial half of the vaginal canal is broad, and the cervix protrudes as a hemispherical bulb into this cavity. The lumen of the vagina is narrow in the caudal half. A distinct, but flattened, clitoris is present abutting against the ventral surface of the vaginal wall near the vaginal orifice.

A pair of mammary glands are present, one on each of the ventrolateral sides of the thorax, and the nipples, which are prominent in the parous forms, are directed laterally.

2. *Breeding habits*

The examination of table 1 reveals some interesting features. Pregnant females occur in all the months of the year except August to October. Secondly, two deliveries occur in the year, once during March-April, and a second time during July. Thirdly, within a short period after delivering the young in March-April, every female becomes pregnant again, but after the second delivery in July, the next pregnancy does not commence until the following year. Thus, the period from August-November may be considered as the period of sexual quiescence for this species.

The females collected on 2nd November had not copulated, but all the parous and the mature non-parous females collected on 6th November had undergone copulation as evidenced by the fact that the vaginal canal was full of secretion from the seminal vesicle of the male and the uterine lumen contained sperms. Evidently all mature females copulate in a very sharply defined period in the first week of November. Ovulation takes place after copulation in this species as revealed by the fact that the ovary had not released the ovum in most of the females collected on 6th November, although the females had undergone copulation. Tubal ova and early free blastocysts were present in females collected on 9th and 17th November respectively. Unmistakable early pregnancy as indicated by the swelling of one of the uterine cornua was noticed in several females collected on 20th November (Pl. I—fig. A).

Table 1 and Pl. I fig. A reveal that not all the females become pregnant in November, and during the period from 9th November to 19th December there were many pregnant and a few non-pregnant females in each collection. Whereas all the parous females collected during this period were pregnant, among the non-parous females only some were pregnant. The parous females can be distinguished from the non-parous ones on the basis of the nature of the mammary nipples, which are large in the former and insignificant in the latter. The stage of pregnancy was more or less the same in all pregnant females collected on a given date during this period (Pl. I—Fig. A). This indicates that pregnancy must have started at about the same time in all these females.

Every female collected between 22nd December and 13th of the following March was pregnant. The absence of non-pregnant females in the collections during this period cannot be an accident because several collections were made during these months. Moreover, mention has already been made that there is no segregation of the specimens on the basis of sex, age or season. Hence, the data lead to the inevitable conclusion that all females are pregnant during the period from 22nd December to the middle of the following March. Evidently, the few non-parous females, which do not copulate until 19th December, undergo copulation about this time and become preg-

nant. Thus, in each collection during the months from January to the middle of March the females could be recognized into two distinct categories on the basis of the size of the gravid uterine cornu. Some were distinctly in more advanced stages of pregnancy than the others, pregnancy having commenced in the beginning of November in the former and in the third week of December in the latter (Pl. I —Figs. B & C). The young ones were delivered also in two batches—the first during the middle of March and the second during the last week of April or early in May.

A very early stage of the development of the embryo (cleaving egg) was noticed in a female collected on 9th November, and a female with an young at the breast was captured on the 13th of the following March. This must have delivered the young just a few hours before capture as borne out by the facts that the umbilical cord was still having a blood clot, the eyes of the young one were not yet open and there was a large clot of blood in the vagina of the mother. Therefore, one can conclude that the gestation period is about 125 days allowing a margin of a couple of days on either side from the date of which the cleaving egg was noticed (9th November) to the date of parturition (13th March).

Within a short time after the young are delivered in March-May, the females undergo copulation, and a second pregnancy commences within a few days after parturition. Every adult female experiences post-partum pregnancy during this period. This is revealed by the fact that every female in lactation collected during March, April and May was also pregnant. In each of these cases the second pregnancy was borne in the uterine cornu contralateral to the one in which the previous pregnancy was carried. Hence, the adult females collected during March, April and early May are either in advanced stages of pregnancy or they have delivered the young and have again become pregnant (Pl. I—Fig. D). Since parturitions of the first cycle occur in two batches, the pregnancies of the second cycle also commence in two batches. The first batch of pregnancies of the second cycle begins about the third week of March and the second batch about the end of April or the beginning of May.

A few young ones, free from their mothers, were collected on 19th April. Assuming that these were delivered in the first batch (about 13th March), it is evident that the lactation period lasts for about 35-40 days. During this time the females carry an young each at the breast and an embryo in one of the uterine cornua. Thus, the lactation period of the first cycle overlaps the gestation period of the second.

Although every adult female becomes pregnant after parturition in March-May, it appears as if the second pregnancy does not go to completion in all the females. From about the beginning of June progressively more and more females appear to lose their embryos as revealed by the fact that, amongst the adult females collected during June and early part of July, there were some which were non-pregant. (The exact manner in which the embryos are lost is not known). Consequently, the number of females, which deliver the young in the second cycle, is much less than the number that becomes pregnant in March-May. Females in very advanced stages of pregnancy were collected on 10th July 1965. Many females, each carrying an young one at the breast, were collected on 24th July 1965. From the size of the attached young ones, whose body weights ranged from 14 to 15 gm, one can conclude that these might have been delivered 2 to 4 days before. Since the gesta-

tion period has been shown to be of about 125 days, it is evident that such of the females which deliver the young around the 20th July must have conceived some time in the third week of March.

No female was found to be pregnant after the 24th of July. This suggests that all the females, which experience post-partum pregnancy late in April must have lost their embryos, because, if these females had carried the conceptus to full term, they should have delivered the young some time during the end of August or the beginning of September, since the gestation period is about 125 days. Obviously, these must have been the few females, which had not copulated until the 19th December in the previous year, but underwent copulation and became pregnant about this time in the previous year.

There is perhaps a considerable loss of the new born young during July and the following weeks, as revealed by the fact that during July and August, although several females in full lactation were collected, many of these were not carrying the young at the breast.

The pregnancy cycles of *Rousettus leschenaulti* can be summarised as follows:

First Cycle: From November to the end of the following April. This includes two waves of pregnancy as follows—(1) Copulation during the early part of November and parturition about the middle of the following March. This refers to all the parous females and to a few non-parous females. (2) Copulation about the third week of December and parturition at about the end of the following April or early in May. This applies to the few non-parous females, which had not copulated in November.

Second Cycle: Post-partum pregnancy from March-May to about the third week of July. In this are included two waves of pregnancy as follows—

(1) *Copulation in about the third week of March followed by pregnancy.*

This refers to all the females which deliver the young ones during about the middle of March. It is not certain if all these females carry the pregnancy to full term and deliver the young. There may be some loss of embryos. Those females, which do carry the foetuses to full term, deliver the young by the end of the third week of July.

(2) *Copulation during the last week of April or early in May.*

These invariably lose their embryos and hence they never carry the pregnancy to full term.

From the foregoing account of the breeding habits of *Rousettus leschenaulti* it is evident that this species, with two quick pregnancies in a year, incorporates both the Autumn breeding pattern as in most other Pteropidae so far described (Baker & Baker 1936; Marshall 1947) and *Megaderma lyra lyra* (Gopalakrishna 1950; Ramakrishna 1951; Ramaswamy 1962) and *Hipposideros fulvus fulvus* (Patil 1968) among the Microchiroptera, and the spring breeding pattern as in several tropical and sub-tropical Microchiroptera (Baker & Bird 1936; Gopalakrishna 1947, 1958; Brosset 1962a,b,c, 1963; Anand Kumar 1965). In experiencing a quick post-partum oestrus, *Rousettus leschenaulti* resembles *Cynopterus sphinx sphinx* (Ramakrishna 1947) amongst Megachiroptera and *Nycteris luteola* (Matthews 1942), *Desmodus rotundus* (Wimsatt & Trapido 1952) and *Taphozous longimanus* (Gopalakrishna 1954, 1955) amongst the Microchiroptera.

3. *Number of young and the symmetry of the female genitalia.*

In each pregnancy *Rousettus leschenaulti* bears a single young, either in the right or in

the left cornu of the uterus. Evidently, there is no physiological dominance of one side of the genitalia over the other. Further, pregnancy alternates between the two sides of the genitalia in successive cycles (Gopalakrishna 1964, 1969). Thus, after delivery in March-April, the next pregnancy (which follows within a few days after delivery) is carried in the cornu contralateral to the one in which the earlier pregnancy was borne. This is evidenced by the following facts. In most of the females, in which early pregnancy was noticed in the second cycle, the contralateral uterine cornu had not come back to normality. The corpus luteum of the previous pregnancy could be detected in the ovary of the contralateral side for quite some time after the second pregnancy had started. This was conclusively demonstrated for this animal by Gopalakrishna (1964). In those females, which carry the pregnancy to parturition in July in the second cycle, the corpus luteum of this pregnancy remains until even after the next pregnancy commences in the following November, so that, in these animals, the pregnancy in the second year occurs in the cornu opposite to the one in which pregnancy occurred during the previous summer. Apparently, the protracted persistence of the corpus luteum until about mid-pregnancy of the next cycle is an important factor which brings about a regular alternation in ovulation between the two ovaries. It is not possible to state as to whether this would be the case with regard to those females from which the embryos were lost during the summer pregnancy. There does not appear to be any physiological dominance of one side over the other in the females experiencing their first pregnancy.

Except some members of the family Vespertilionidae (Lyon 1903; Ramaswami 1933; Gopalakrishna 1947; Uchida 1950; Madhavan 1971), which normally bear more than one young in each litter, most other bats, which have been so far studied, carry a single young in each litter. In such monotocous bats there is a tendency for the physiological dominance of the right side over the left side (Robin 1881; Jones 1917; Matthews 1937, 1942) except in *Megaderma lyra lyra* (Gopalakrishna 1950; Ramakrishna 1951; Ramaswamy 1962) and *Hipposideros fulvus fulvus* (Patil 1968) where the left side shows dominance. In *Rhinolophus hipposideros minutus* (Matthews 1937) the left ovary does not even produce mature ova. Pregnancy alternates between the two sides of the genitalia in successive cycles in *Desmodus rotundus* (Wimsatt & Trapido 1952) and *Taphozous longimanus* (Gopalakrishna 1954, 1955), where a single young one is brought forth each time. The condition in *Rousettus leschenaulti* is, therefore, similar to that in *Desmodus rotundus* (Wimsatt & Trapido 1952) and *Taphozous logimanus* (Gopalakrishna 1954, 1955).

4. *Growth and maturity.*

There seems to be a considerable difference between the males and the females with respect to the age at which sexual maturity is attained in *Rousettus leschenaulti*. Table 1 reveals that during the breeding season, whereas all the females become pregnant, many males have immature gonads. This indicates that the females attain sexual maturity in the very first breeding season after their birth, but the males do not attain sexual maturity until at least the second breeding season. Further, the lowest body weight of the female showing unmistakably pregnancy is 55 gm, but in the case of the males their gonads are immature until they reach a body weight of 73 gm. Hence, the weight at which the sexual maturity is reached is about 55 gm in the females and about 73 gm in males.

(a) **Female**

The new born young weighs about 12 gm as is evidenced by the fact that the lowest body weight of the young one attached to the breast of the mother was 12 gm, and the highest weight of the foetus at full term was also 12 gm. The first wave of delivery pertaining to the first cycle occurred in the middle of March, and the first batch of young ones free from the mothers' breasts were collected on 19th April. The lowest body weight of the free young one was 37 gm. Evidently, the mothers carry their young for about 35 to 40 days during which period the young grow very rapidly and increase by nearly three times in their weight before they are weaned. The second batch of young ones are delivered during about the last week of April so that young ones of two distinct sizes are noticed from May onwards, and these correspond to the two batches of young ones delivered in the two waves of the first cycle, the first batch about the middle of March, and the second by the last week of April. One could, therefore, easily identify the young ones delivered in the first wave because they have significantly higher body weights than those delivered in the second week. It is, therefore, possible to trace separately, up to a certain stage, the growth of the animals born in the two waves. If it is assumed that in each collection after the pregnancy cycle the highest body weight recorded amongst the young ones relates to the young born in the first wave of delivery, then the females born on the 13th of March would reach a body weight of 37 gm on the 19th of April, 44 gm on 13th May, 50 gm on 27th June and 52 gm on 10th July. These are the highest body weights of young ones collected on the respective dates. These young should reach a body weight of 55 gm (weight at maturity) by the middle of August. The pattern of growth of the young ones, as indicated by their body weights, is given in text-fig. 1, which is a scatter diagram of the body weight of the females collected during the different months of the year. The curves indicate the pattern of increase in the body weight of the young during growth. The female born in the second wave of delivery, that is, during the latter part of April, have a similar pattern of growth, and these should attain 55 gm of body weight by about the end of September. Thus, by the beginning of November, that is, at the onset of the breeding season, the young ones born in the middle of March as well as those born during the latter part of April would be sexually mature. Further, since on the 6th November every female with a body weight of over 55 gm had copulated, it clearly shows that the females born during March-April copulate in the beginning of November, that is, at the age of about 7 to 8 months.

According to the pattern of growth as mentioned above, the females born during the third week of July in the second cycle should be reaching a body weight of 55 gm only by the third week of December, and hence they could not copulate in November. These are evidently the few non-parous non-pregnant females occurring in the collections between 6th November and 22nd December. After these animals reach the weight of 55 gm (by the third week of December) they also undergo copulation so that every female is pregnant after the 22nd of December. Therefore, the females born in the third week of July copulate when they are about 5 months of age.

From the foregoing it is evident that in the month of November the females can be assigned to one of the following categories—

(1) Parous females which are at last 16 months old. These are the ones born latest in

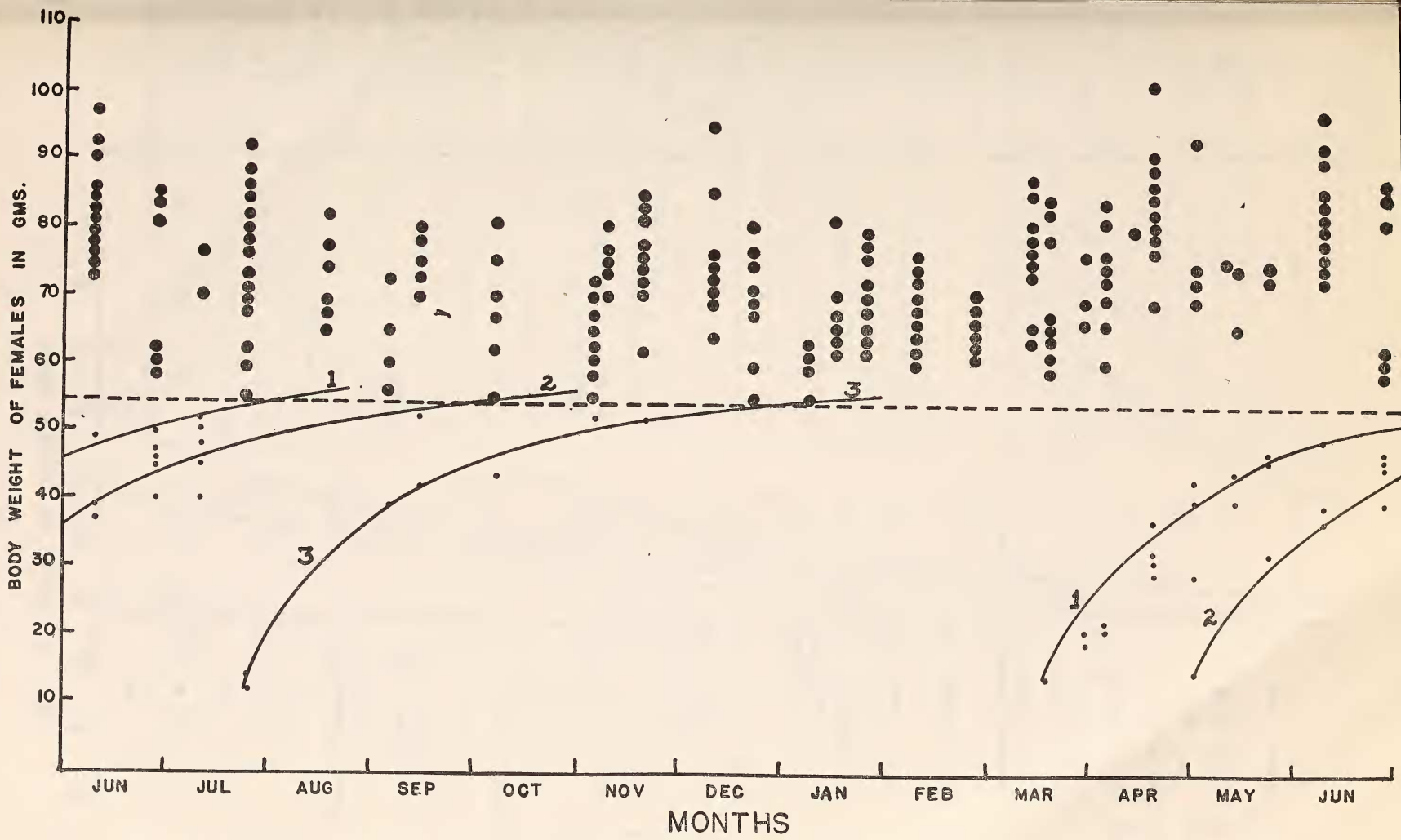

Fig. 1. Scatter diagram of the body weight of the females collected during the different months of the year. The curves numbered 1, 2 and 3 indicate the pattern of increase in the body weight of the young born in the three waves of delivery in a year. The dotted line indicates the weight at sexual maturity. Please seee text for details.

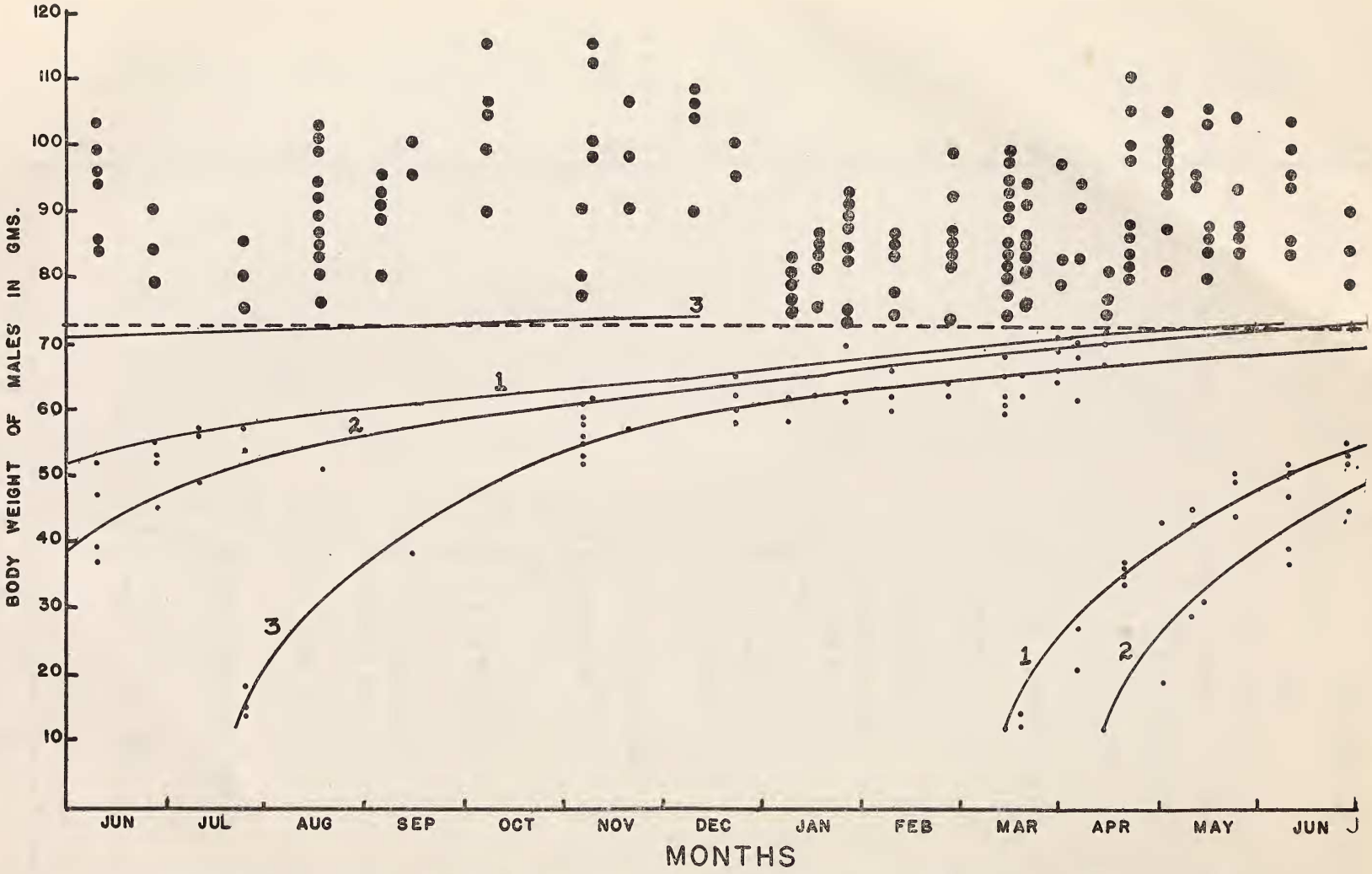

Fig. 2. Scatter diagram of the body weights of the males collected during the different months of the year. The curves numbered 1, 2 and 3 indicate the pattern of increase in the body weight of the young born in the three waves of delivery in a year. The dotted line in the graph indicates the body weight at sexual maturity. Please see text for details.

July of the previous calendar year. All these copulate early in November.

(2) Non-parous females which were born either in March or in April of the year. These are 7 to 8 months old. These also copulate early in November.

(3) Non-parous females which were born in July of the year. These do not copulate in November, but copulate sometime during the third week of December when they are about 5 months old.

(b) **Male**

The pattern of growth of the young males is similar to that of the females except that the males do not reach sexual maturity until they attain a body weight of at least 73 gm, this being the lowest body weight of a male showing spermatogenesis in the testis. Text-figure 2 is a scatter diagram of the body weights of the males collected during the different months of the year, and the curves indicate the pattern of growth of the young males. From the growth pattern indicated by the graph it is evident that the males take about 14 months to attain a body weight of 73 gm. Hence, the males born in March-April would be reaching this weight by May-June of the following year. Since the breeding season does not set in until the following November these males can participate in successful copulation only when they are about 19 to 20 months of age. The males born in July would also be reaching a body weight of 73 gm by the end of October of the following year, and hence they should also be able to copulate in November of the following year when they would be about 15 to 16 months of age. Males born in March-April as well as those born in July can take part in their first copulation only in November of the following calendar year earliest. Thus, they should be at least 16 months old before taking part in copulation in the case of those born in July, and 20 months old in the case of those born in March.

The work on other species of bats has revealed that the age at which sexual maturity is attained varies in different species. Baker & Baker (1936) working on *Pteropus geddiei* and Baker & Bird (1936) working on *Miniopterus australis* have not made a specific mention about the growth and maturity of the respective species which they studied, but from Table 2 on page 128 (Baker & Baker 1936) and Table 1 on page 153 (Baker & Bird 1936) it is apparent that during the breeding season many non-pregnant females were also collected along with the pregnant ones. Apparently, in these species the females do not experience their first oestrus in the year of their birth, and are, therefore, over 16 months of age, when they experience their first oestrus. Matthews (1937) working on two species of British horseshoe bats, has shown that in these species the females do not reach the first oestrus until their second Autumn when they are at least 15 months old. Miller (1939) states that "young males of *Myotis lucifugus lucifugus* and *Myotis greisescens* do not enter into reproductive activity until their second spring". Working on *Megaderma lyra lyra* Ramaswamy (1962) mentioned that the animals in this species "do not reach sexual maturity within the year of their birth, and very likely not until at least the Autumn of the next year. Since the males seem to be a little ahead of the females in the onset of sexual activity, the males probably do not become mature until they are at least 15 months old, and the females at least 18 months old". Anand Kumar (1965), remarked that in *Rhinopoma kinneari,* "both the young male and female bats do not reach sexual maturity at least until their second year". Patil (1968)

recorded that *Hipposideros fulvus fulvus* does not reach sexual maturity in the first breeding season and the specimens should be at least 18 months of age when they attain sexual maturity.

Whereas the literature cited above shows that many species of bats do not attain sexual maturity until at least the second year of their birth, there are a few species which attain puberty within the year of their birth. Gopalakrishna (1947, 1948) has shown that in *Scotophilus wroughtoni* sexual maturity is reached in both the sexes before the specimens are one year old. Pearson *et al.* (1952) showed that in *Corynorhinus rafinesquei* "the young females only four months old mate as early as do the adults", but young males do not copulate in their first year. In *Myotis lucifugus lucifugus,* whereas the females born in June undergo copulation in the following September (Wimsatt & Kallen 1957), the males do not attain sexual maturity until their second Spring (Miller 1939).

Rousettus leschenaulti is a fairly large bat with the males reaching a maximum weight of 115 gm and the females 101 gm. It is interesting that such a large bat reaches sexual maturity within a few months whereas many bats much smaller in size take a longer time. As an example one can cite the case of *Hipposideros fulvus fulvus* (Patil 1968), whose adult maximum body weight (about 10 gm) is less than the weight of the full term foetus of *Rousettus leschenaulti,* but which reaches puberty in its second season, that is, at the age of about 18 months. Apart from the genetic factors, which determine the growth and maturity, perhaps the very rapid growth of the young during the sucking stage and during the following few weeks, coupled with the fact that there are two cycles of pregnancy occurring in quick succession, may help in accelerating maturity in *Rousettus leschenaulti.*

(c) **Mortality**

Since every female becomes pregnant twice in the year, each female should theoretically produce two young in a year. If all the young survive the number of young at the start of the breeding season should be more than the number of the adult specimens because the adult females out-number the males in the total population, and, further, it is normally expected that a certain number of very old adults should die due to natural old age. But in actuality, at the beginning of the breeding season the number of the first year young animals (including the non-parous females which are only a few months old) is much smaller than the number of adults. Out of 118 females there were only 34 young ones, and out of 104 males there were only 35 immature ones during the beginning of the first cycle of the breeding season, that is, between 6th November and 22nd December. This small number of immature ones can only be due to the loss of the embryos and/or the delivered young ones. It has already been stated that many pregnant females lose their embryos in the second cycle, and that there is a considerable loss of the new born young delivered in July as indicated by the fact that during July and Aug. many females in full lactation were collected but without the attached young. The period when there appears to be the greatest loss of the young is when the young are between 20 to 35 gm in weight, that is when they are between 15 to 30 days of age. The small young whose weight is less than 20 gm adhere very fast to the nipples of the mothers. The sharp teeth of these young appear to be sunk deep into the skin of the nipples, and the young can be removed from the mothers' nipples only by applying considerable force. Up to

this age, therefore, there does not appear to be much loss of the young. But the young ones over the weight of about 20 gm get easily detached from the mothers, and in fact they were often found to have crawled away from their mothers in cages in which they had been kept overnight. Thus, either due to adventurism on the part of the young or due to accidents they get detached from their mothers, and once detached, the mothers do not try to bring the young back to their breasts. Since these young are very helpless and are not big enough to lead an independent life, they are lost.

5. *Sex ratio*

Among the 1367 specimens collected 759 (55.26%) were females and 608 (44.74%) were males. Since the collections were made at random, and since there is no segregation of the two sexes on the basis of age or reproductive activity, the sex ratio as is evident from the collection can safely be taken as the natural sex ratio in this species. Amongst the young ones collected from the breasts of the mothers the number of males and females was nearly the same (49 and 51 respectively). Evidently, the males and the females are born in equal numbers, but during the growth period there appears to be a higher mortality among the males. Hence, in the total population the females outnumber the males.

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